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Macro-Economic Impact and Other Considerations in Selecting Energy Conservation Measures

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Prepared for

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16. Abstracts

This report presents concepts and numerical estimates required for a complete and an objective evaluation of energy conservation. The underlying premise is that conservation, like any government program, has costs and benefits that should be quantified and compared. The research for this report had two objectives: (1) to evaluate the macro-economic impacts of energy conservation, and (2) to estimate and present the costs of and benefits from energy conservation.

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MACRO-ECONOMIC IMPACT AND OTHER CONSIDERATIONS IN SELECTING ENERGY CONSERVATION MEASURES

Submitted to

PEAT, MARWICK, MITCHELL AND COMPANY
and
ENVIRONMENTAL PROTECTION AGENCY

June 16, 1975

FINAL REPORT

Submitted by

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SUMMARY

This report presents concepts and numerical estimates required for a complete and an objective evaluation of energy conservation. The report departs from the often expressed feeling that energy conservation is "required" and, therefore, the terminology and the quantifications are different than some readers have encountered in most discussions of energy conservation. The underlying premise in this report is that conservation, like any government program, has costs and benefits that should be quantified and compared: if conservation is desirable, reliable estimates of costs and benefits should verify this fact.

The research for this report had two objectives: (1) to evaluate the macro-economic impacts of energy conservation, and (2) to estimate and present the costs of and benefits from energy conservation. The concepts in this report are applicable to all energy conservation, but the numerical estimates are for a specific set of eight energy conservation measures which were evaluated in a separate report.

The specific conservation measures analyzed in this report are described in Appendix A and summarized below:

Individual Conservation Measures	10^{12} Btus Saved 1980	1985
A. Solid Waste as Fuel in Power Generation	97	447
Direct combustion of solid waste is prompted by incentives from various government programs.		
B. Waste heat recovery in power Generation	1431	4496
Recovery and use of waste heat to reduce fuel requirements is encouraged by economic incentives.		

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C.	Improved Automobile Gasoline Efficiency	1690	2790
	Increased efficiency is from auto design changes and user maintenance as a result of voluntary and mandatory changes.		
D.	Recycling High-Energy Materials	15	97
	Government subsidies would encourage scrap collection and recycling over raw materials which require more energy-intensive processing.		
E.	Substitution of Bus for Auto Use	248	414
	People are encouraged to use the bus over autos as a result of parking taxes and lower bus fares.		
F.	Improved Energy Efficiency in Appliances	1348	2221
	Government regulations on minimum energy efficiencies would reduce energy consumption.		
G.	Less Energy for Home Heating and Cooling	383	647
	Public appeals for lower thermostat settings during heating and higher settings during cooling seasons will decrease residential energy use.		
H.	Less Energy for Commercial Building Heating & Cooling	683	841
	Appeals like those for residences will lower energy used for temperature control in commercial buildings.		

For 1980, the total of 5.9×10^{15} BTUs from all eight measures is 6.1 percent of the projected 96.02×10^{15} consumption--i.e , projected consumption without energy conservation or energy shortages.

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The micro-economic analyses, the direct impacts, and the feasibility of each of the above conservation measures are analyzed in other reports (see References 7 and 17); estimates and conclusions from these analyses were the inputs for the macro-economic analyses in this report.

Macro-economic impacts from energy conservation are summarized in two parts: (1) expected reductions in Gross National Product--the value of all goods and services produced and (2) expected inflation--the increase in the cost per unit of goods and services. Unemployment effects are not analyzed because they have been presented in a separate report.

The set of eight conservation measures listed above will reduce GNP 1.4 percent in 1980. That is, GNP will be 1.4 percent less than what it would be without the eight conservations measures that will reduce energy consumption by 6.1 percent. The estimated 1.4 percent should be valid over the range of feasible levels of GNP in 1980, but the most probable impact is a reduction from an expected 1.060 to 1.046 trillion in 1958 dollars.

The 1.4 percent reduction in GNP arises in four major areas: a .5 percent reduction from direct reduction in energy sales--an unavoidable reduction since reduced energy use is the goal of conservation; a minor reduction from bottlenecks in implementing conservation measures; a .4 percent reduction from demand response to higher prices; and a .4 percent reduction from the economic multiplier effects. These sub-components indicate how GNP impact estimates were developed, and they indicate the reasons for the reductions, as delineated in Section 4 and Appendix C.

The specified set of eight conservation measures have been designed and described in a manner that indicates no inflationary effects; in fact, the specifications suggest that the effects could be deflationary. The reason is that the eight pre-selected measures were screened so that no specification requires energy users to spend more than they would have without the conservation.

It is necessary to estimate the benefits from conservation in order to determine if total costs and sacrifices--a total in which the above macro-economic effects are one component--are justified. The best estimate of benefits in 1980 for the 6.1 percent energy reduction from the eight specified conservation measures are as follows:

2¢/MBTUs for pollution reduction. This applies to the total of 5.9×10^{15} BTUs in all of the pre-selected eight measures; in other words, the 2¢ estimated pollution costs for each MBTU can be avoided when the energy use is eliminated.

11¢/MBTUs for slower energy depletion. This also applies to the total of 5.9×10^{15} BTUs.

14¢/MBTUs for reducing import vulnerability. This applies to 5.1×10^{15} BTUs, or 80 percent of all energy savings from the eight measures.

28¢/MBTUs for eliminating inefficient energy uses. This applies to the 1.3×10^{15} BTUs saved by improving the energy efficiency of appliances--Measure F.

The benefits are expressed in terms of cents per energy unit in order that the reader can compare benefits with market prices of energy.

The above four estimates cannot be added without reviewing the specific conservation measures. For example, only one of the pre-selected eight conservation measures generates all four benefits, a total of 55¢ per million BTUs (MBTUs). In this case, the 55¢/MBTUs benefits are quite large, at least they are quite large relative to market prices for energy. For example, they are 30 percent of the 130¢/MBTU in a typical $10/barrel price of crude oil and 9 percent of the typical 600¢/MBTUs for residential electricity.

Total annual benefits from all eight measures in 1980 are $1.8 billion--.12 from less pollution plus .65 from slower energy depletion plus .71 from reduced import vulnerability plus .36 from eliminating inefficiencies. The advisability of implementing this set of eight measures should be determined by comparing the estimated benefits with estimated costs, including lower GNP, higher unemployment, higher cost of energy substitutes, and reduced welfare from any sacrifices in comfort and convenience. Unfortunately, there is no accepted procedure for converting the estimated 1.4 percent GNP reduction and other cost components into dollars for obtaining a total cost that can be compared with the estimated $1.8 billion benefits described above.

The approach for estimating and comparing costs and benefits in the main report, as well as the numerical estimates summarized above, should help in the search for the best mix and the best level of energy conservation. Estimates can be improved as more data become available and more procedures for converting conservation impacts into dollar values are developed.

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MACRO-ECONOMIC IMPACT AND OTHER CONSIDERATIONS IN SELECTING ENERGY CONSERVATION MEASURES

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FOREWORD

This report is based on Phase Two of a Jack Faucett Associates sub-contract to Peat, Marwick, Mitchell and Company under their contract 68-01-2440 with the Environmental Protection Agency.

The Jack Faucett Associates' research focused on estimations of economic impact of a set of conservation measures selected by the Environmental Protection Agency and Peat, Marwick, Mitchell and Company.

SECTION 1

STUDY OBJECTIVES AND STUDY INPUTS

This study began with a focus on macro-economic impacts of energy conservation, including numerical estimates of expected reductions in GNP for several levels of energy cutback. The interim report (24) provides concepts and estimates under the original concept.

This report reflects an expansion of the study focus to include benefits from energy conservation. This new focus permits a preliminary assessment of both costs and benefits from conservation. The emphasis is on developing a complete quantification even when it is necessary to use first-approximations or add assumptions.

The objectives can be stated in two general questions:

1. What are the expected benefits from the eight pre-selected conservation measures?

2. What are the probable macro-economic effects of the eight pre-selected conservation measures?

The base year for evaluation in this report is 1980. The baseline for measuring benefits and macro-economic impacts is the expected economic and environment conditions without energy conservation. Essential parts of the baseline are shown in Figure 1.

All estimates of benefits and macro-economic impacts are the expected differences with and without the energy cutback specified in the eight pre-selected measures identified below.

Research for this report was limited relative to the great importance of conservation. The overall analysis was possible only by using other research, by developing estimates in the context of a specific economic/environmental background, and by adding assumptions in key areas where resolution of uncertainties was infeasible. The remainder of this section presents a complete delineation of the three sets of specifications so readers can judge better the reliability of study results and make improvements to the extent that they can improve upon the assumptions, the background, and the inputs.

The eight individual conservation measures specified as input to this study as as follows:

A. Use solid waste as fuel in power generation.

B. Recover and use waste heat in power generation.

C. Improve gasoline efficiency of automobiles.

D. Recycle materials for which original production is energy intensive.

E. Increase bus transit relative to automobile.

F. Establish minimum energy efficiency for appliances.

G. Change residential thermostat settings.

H. Change commercial building thermostat settings.

The specific means for implementing each measure is specified in a report to EPA (Ref. 7). For evaluating economic impact of energy conservation and evaluating the success in implementation, the three-part classification in Table 1 is useful:

- the public appeal and public information approach--e.g., Measure G calls for people to voluntarily lower thermostat settings and it provides information on energy saving from the same.

- price adjustment approach--this can be a tax on energy or it can be a subsidy as in the case of Measure A which calls for tax concessions for power plants that use solid wastes as fuel.

- direct control approach--e.g., Measure A calls for mandatory changes in automobile design.

This report does not include an evaluation of advantages and disadvantages of each implementation approach, but it does include analysis of impacts which are, in part, determined by the implementation approach.

As shown in Table 1, the evaluation of both benefits and costs involve two basic steps:

1. Determine the specific changes such as lower pollution among benefits and reduced energy sales among costs;

2. Estimate the present value of effects under both benefits and costs. The methodology for this two-step process is in Section 3 and Appendices B and C.

TABLE 1.-ESTIMATING BENEFITS AND COSTS FOR EVALUATING CONSERVATION

	Basic Approach for Implementing Conservation		
	1. Public Appeal/ Information Approach	2. Price Adjustment Approach	3. Direct Control Approach
Examples	Public appeal to lower thermostat	Gasoline tax	Min. Miles/Gal. Requirement
Benefits from Conservation			
1. Reduced Pollution 2. Slower Energy Depletion 3. Reduced Embargo/Monopoly Vulnerability 4. Fewer Inefficient Energy Uses	First determine specific changes such as lower sulfur emissions and lower imports, and then estimate the present value (benefits) of these changes for society.		
Costs of Conservation			
Macroeconomic 5. Short-Run Adjustment 6. Long-Run Restraint	First identify the chain of economic reactions if specified conservation measures are implemented and then estimate what society would be "willing-to-pay" to avoid the entire chain of reactions if conservation goals could be obtained without conservation.		
Willingness-to-pay 7. Short-Run 8. Long-Run			

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If implemented reasonably soon, conservation measures A-H could reduce energy use by 5.9×10^{15} BTUs in 1980 (Ref. 7). This reduction would be 5.9 percent of the projected energy demand under normal price changes and no explicit government action between now and 1980--see baseline predictions in Figure 1.

Inputs to this study included the following information on each of conservation measures A-H:

1. Description of the implementation mechanism that will entice or force the specified conservation (See summary on the first row of Table 2).

2. The expected and maximum reduction in BTUs for 1977

3. Verification that the conservation measure is feasible with respect to technology and resource requirements.

4. The immediate economic impact on the industry or economic sector which must implement the conservation measure

5. Selected estimates of the cost in changing to a mode of operations consistent with the specified conservation.

All of these inputs were accepted as stated. A summary of detailed inputs and examples of numerical estimates are given in Appendix A. A brief summary of the above types of input information is given below.

The basic mechanism for implementing each conservation measure and a ranking of expected benefits from each is shown in Table 2. Four of the measures fall within the "price adjustment" mechanism, but only in a special way. Whereas a normal price

TABLE 2. - CLASSIFICATION OF SELECTED CONSERVATION MEASURES[a]

	Basic Mechanism for Implementing Conservation								
	Public Appeal/ Information Approach			Price Adjustment Approach				Direct Control Approach	
Measures A-H (Page 2)	C_2	G	H	A	B	D	E	C_1	F
I. Benefit Categories with Ranking of each Measure									
1. Reduced pollution		3rd	3rd	?	3rd		2nd		
2. Slower energy depletion		1st	1st	1st	1st	1st	1st	2nd	1st
3. Reduced embargo/monopoly consequences		2nd	2nd	2nd	2nd		1st	1st	
4. Fewer inefficient energy uses[b]	3rd								?
II. 1980 Energy Reduction (10^{15} BTUs per year)[c]	.4	.4	.7	.1	1.4	.01	.23	1.3	1.3

[a] *See list of conservation measures A-H on page 2. Note, the numbers in Part I are a ranking, while the numbers in Part II are BTUs; e.g., conservation measure B saves 1.4 X 10^{15} BTUs in 1980, with the greatest benefits occurring in Category 2.*

[b] *This refers to an inefficiency at the true social cost of energy, e.g., an inefficiency exists if a $1.00 increase in the cost of producing an appliance can lower energy usage rates by amounts that have a present value greater than $1.00.*

[c] *The total BTU savings of all 8 conservation measures are approximately 5.9 percent of the estimated normal 1980 energy consumption as shown in Figure 1.*

adjustment is to increase the market price of energy which is to be conserved, an alternative is to lower the cost (Price) of substitutes for the specified energy. The detailed explanation of Conservation Measures A, B, D, and E is as follows:

A. Use of solid waste is encouraged by providing tax credits and above-normal depreciation rates that, in essence, make solid waste a cheaper fuel than conventional energy (generally coal).

B. Waste heat recovery is encouraged by tax credits and above normal depreciation rates that, in essence, make recovery cheaper than new energy.

D. Recycling scrap steel/other materials is encouraged by government subsidies for capital investment which, in essence, makes recycling cheaper than using new resources; energy is conserved because recycling is less energy intensive.

E. A shift from private automobile to bus transit is encouraged by subsidies that (1) allow reduction in bus fares and (2) cover the extra cost of better bus service--more frequent service, better routing, faster service, etc.-- and is encouraged by a tax on private automobile parking; both the subsidy and tax encourage bus transit by decreasing bus cost/inconvenience relative to that for automobiles.

Although there is no question that the above are price adjustments, there is reason to question whether the normal allocation efficiency of pricing will occur. Efficient use of resources can occur only if all prices are set equal to cost; lowering the cost of energy substitutes instead of raising the cost of energy introduces obvious price distortions and, therefore, inefficiencies.

Direct control is specified as the implementing mechanism for two of the conservation measures:

C. Better energy efficiency in automobiles
   - Mandatory use of radial tires
   - Mandatory aerodynamic design
   - Mandatory variable transmissions

F. Minimum energy efficiency for appliances.

With direct controls we remove the uncertainty about implementation that is present with price adjustment and public appeal/information, but we introduce uncertainty about the true cost of conservation. With price adjustment--but not with mandatory controls--the consumer is free to continue energy use if economic analysis indicates that his cost/sacrifice is too high relative to prices he pays for energy.

The public appeal/information approach is specified for two and part of a third measure:

C. Increasing automobile efficiency through voluntary engine tune-up

G & H. Lower thermostat settings are strictly voluntary in the case of residences and primarily voluntary in the case of commercial buildings; it is possible for the public and government agencies to bring pressure on commercial establishments, but this is far from direct controls; and, therefore, is classified as public appeal/information.

The mere classification as public appeal/information does not eliminate the cost of conservation; as discussed subsequently,

the proper measure of cost is what people are willing to pay to avoid the consequences of conservation, including the inconveniencies and discomforts. In essence, the public appeal/information approach asks the energy consumers to do the evaluation.

Besides specifying the implementation mechanism, Table 2 also indicates a ranking of benefits from each specified measure. A short summary of the ranking for each conservation follows:

A. Using solid waste as fuel is largely conservation of coal and, therefore, the primary benefit is Number 2 --slower depletion of energy resources. There is only small benefit in Number 3--reducing oil imports--because other factors will probably reduce oil consumption in power generation. It is questionable if the pollution from solid waste burning will be less than from coal, especially after pollution control devices are added in coal-burning plants.

B. Waste heat recovery has primary benefits in reducing fossil fuel consumption, secondary benefits in oil consumption to the extent oil is still used in power generation, and some benefits in pollution control to the extent that control devices are not completely effective. Except for water temperature, thermal pollution is only a selective problem because the average temperature over the U.S., even with the large energy use, is predicted to decrease.

C. Improved automobile efficiency has primary benefits in reducing embargo consequences and secondary benefits in slower resource depletion and pollution. It is likely that the dollar value/BTU reduction in this conservation measure is greater than for any other measure, with the possible exception of increasing bus transit.

D. Recycling materials is so small a factor that benefits only register in Number 2--delaying energy resource depletion.

E. The switch from private automobile to bus will reduce energy use, particularly in oil, and it will reduce pollution because of smaller energy consumption/passenger mile. However, the benefits are limited if bus miles and travel time increase significantly

in order to provide the better service essential for attracting riders.

F. Required minimum energy efficiency in appliances will reduce electric power consumption, which, in turn, will reduce coal and some uranium use. It is possible that some appliances are not built in the optimum tradeoff between initial cost and fuel cost and, therefore, we can expect some benefits in Number 4--fewer inefficient energy uses. We must realize, however, that energy efficiency does not represent overall economic efficiency.

G & H. Thermostat settings to reduce air conditioning in summer and heating in winter provide primary benefits in delaying energy depletion and secondary benefits in reducing embargo consequences and pollution. Since natural gas and oil are substitutes , there is a benefit whichever is used in home heating and air conditioning.

The above descriptions of study inputs and discussion of types of benefits are sufficient for delineating important aspects of the background against which costs of and benefits from conservation must be measured. The most important background factors for measuring and interpreting costs can be outlined as follows:

1. Availability of manpower skills and materials for implementing conservation measures
2. State of present technology for conservation measures like use of solid waste as fuel and recycling materials.
3. Vulnerability of the economy to recessionary forces
4. The suddenness with which energy cutbacks are enforced --e.g., the cost of conversion to solid waste as fuel is less if it can be done as new plant investment is required in normal expansion and replacement.
5. Inflationary trends and the vulnerability of the economy to greater inflationary pressure.

Although the inputs to this study include verifications that the first two factors--availability of manpower/material and

technology--do not constitute fixed constraints, we are still uncertain about cost increases. E.g., if use of solid waste is a cost increase equivalent to raising the price of coal $x/ton, there is no constraint but, the $x/ton is a cost in itself and a possible trigger for further inflation. Since the implementation mechanism for using solid waste as fuel is a price adjustment (i.e., a subsidy in the form of a tax credit), the upper limit in cost is the "price adjustment" times "the amount used." Since cost data are sparse, it is necessary to add assumptions about costs.

The current recession and inflation are important background factors in evaluating the cost of conservation. However, there is an offsetting factor that must be considered carefully. If energy conservation is not implemented, the larger energy consumption can increase energy prices and entice foreign oil embargos that can also create inflation and dampen economic growth. The estimates of macroeconomic impact in Section 4 reflect this consideration, since the purpose is to determine the difference with and without energy conservation. The last factor--sudden implementation of energy conservation that can increase costs--can be ignored in this study since the study inputs include verification that the specified energy savings represents reasonable rates of changeover to lower energy use.

The projections of economic variables in the absence of energy conservation and the projection of energy use in the absence of special limitations--major conservation, foreign embargos, or monopoly pricing--are shown in Figure 1. The projections form part of the background for assessing the cost of conservation. For example, the above normal unemployment and inflation rate as of December 1974 are important factors in assessing the vulnerability of the economy to pressure from energy

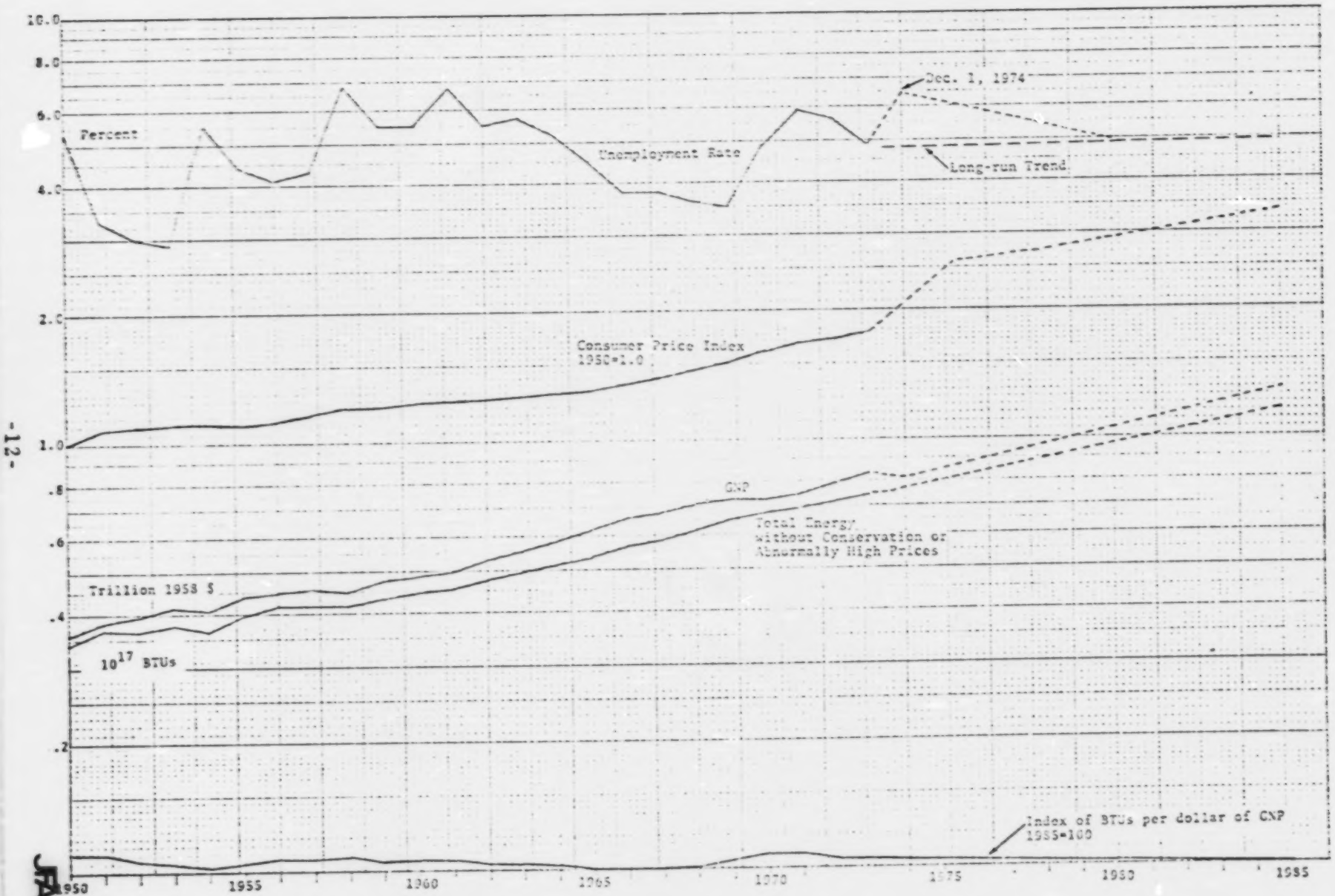


FIGURE 1: HISTORY AND PROJECTION OF ENERGY AND MACROECONOMIC VARIABLES

conservation. Although economic conditions cannot be forecasted accurately, it is important to develop the best possible estimates. The estimates on Figure 1 were developed by adapting estimates in other Jack Faucett Associate projects in energy use and conservation.

The most important inputs for measuring and interpreting benefits from conservation can be outlined as follows:

1. The schedule for pollution control--the contribution of energy conservation to pollution reduction will depend on normal controls and technology; examples are replanting after strip mining, desulfurization in coal-fired power generation, and pollution control devices for automobiles.

2. Domestic energy resources--conservation benefits in slower energy depletion depend, obviously, on the volume of available resources.

3. New fossil fuels--the cost/unit and timetable for oil shale, liquefaction and gasification of coal, and OCS and Alaskan Oil, will effect benefits from energy conservation.

4. Fossil-fuel substitutes--the cost/unit and timetable for the breeder reactor, nuclear fusion, and solar energy, will, obviously, effect benefits from conserving fossil fuels.

5. Future embargos--the probability of foreign oil embargos and increase in prices of foreign oil effect conservation benefits.

6. The willingness of the American public to pay for reducing risks-- the risk of depleting present energy before substitutes are available and the risk that scheduled pollution control devices will not prevent dangerous pollution both increase benefits.

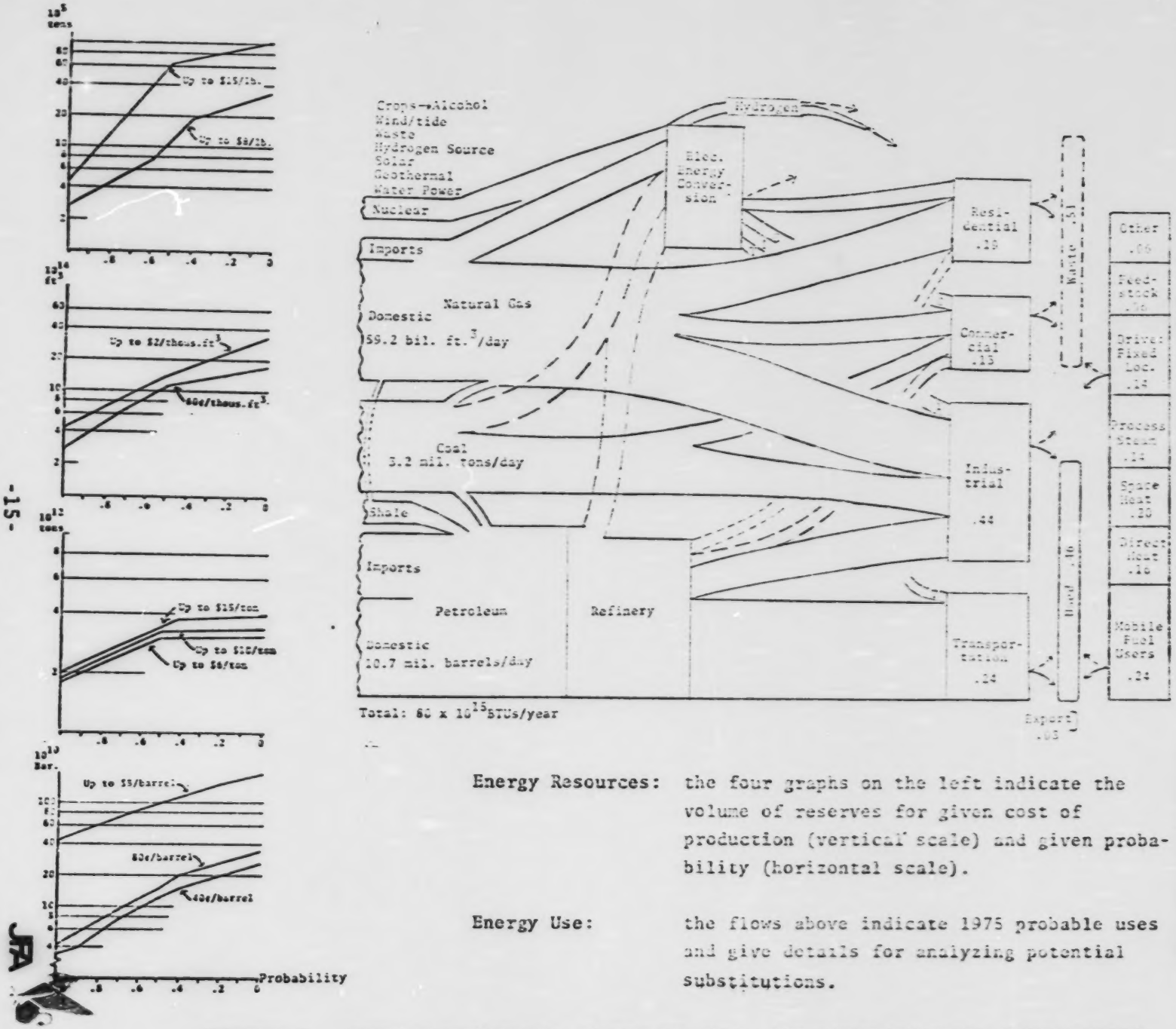
The first and sixth factors are important in measuring benefits in the first category--reduced pollution. The second, third and fourth factors are important in measuring benefits in the second category--slower depletion of energy. The fifth factor

is critical in measuring benefits in the third category--reduced consequences of foreign oil embargos.

Since the eight conservation measures have little direct bearing on pollution control and since this study has major focus on macro-economic impacts, the first background factor is not discussed in detail. Likewise, the desire to avoid risk of environmental degradation, as mentioned in Factor 6, is not discussed further. Factors 1 and 6 are certainly very important for any evaluation of the role of energy conservation in environmental protection, however.

The estimated volumes of domestic fossil fuel resources--Background Factor 2--are shown on the left-hand part of Figure 2. These estimates were developed in another Jack Faucett Associates study on estimation of opportunity costs of energy resources (Ref. 16). The relationship between resources and demand can be determined by comparing the resources and 1975 demand shown in the midpart of Figure 2. E.g., proven reserves of natural gas at production costs of 60 cents or less per thousand ft^3 will be exhausted in 13 years at the 1975 consumption rate of 59 Billion ft^3/day. However, Jack Faucett Associates estimates a 50 percent probability that reserves at 60¢/cft of natural gas are three times the estimated proven reserves of 3×10^{14} ft^3; proven reserves at a cost of $2.00 or less per thousand ft^3 are nearly twice those at 60 cents per thousand cubic feet (see resources at probability = 1.0 and .5 on the horizontal scale in the left-hand part of Figure 2).

The types of estimates shown on the left-hand side of Figure 2 are what is needed for evaluation of energy conservation. They require extension of the estimates most experts are willing to



Energy Resources: the four graphs on the left indicate the volume of reserves for given cost of production (vertical scale) and given probability (horizontal scale).

Energy Use: the flows above indicate 1975 probable uses and give details for analyzing potential substitutions.

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FIGURE 2: ENERGY RESOURCES, RATES OF USE AND ENVIRONMENTAL DEGRADATION

develop, but confining resource estimates to proven reserves or resources at present cost of production is simply unrealistic. Estimates like those in Figure 2 are subject to much qualification, but there is reason to believe that actual reserves are as likely to be greater as they are smaller than shown.

Background Factor 3 was specified in the following format:

Oil Shale: can be available in limited quantities by 1985 @ $13.00/barrel

Liquification of coal: can be available in limited quantities by 1985 @ $13.00/barrel

Gasification of coal: can be available in limited quantities by 1985 @ $1.50/thousand ft^3 or approximately 3 times the 1974 market price of natural gas.

Complete details on quantities by cost/unit and year are very complex, but the above provides a general feel on new fossil fuels.

The remaining background factors for evaluating benefits are specified as assumptions. The breeder reactor is assumed to be available and acceptable for all expansion in electric power needs after 2000. Actually, the only crucial assumption is that it is available and acceptable prior to depletion of the uranium resources being used as fuel in the present light-water reactors. The assumption of acceptability is critical because there is no evidence that danger from radioactivity can be reduced significantly by 2000. There is some evidence that the actual risk is already so small as to be acceptable

to most people, but estimates are far from being generally accepted. Nuclear fusion and solar energy appear to be free pollution but their economic feasibility is probably many decades away.

The critical assumption on the probable acceptance of depleting present energy before substitutes are available is that the probability is too small at present to register as a legitimate concern. Stated otherwise, the significant concern can be captured in the probability of higher costs for new energy.

The critical assumptions on factors related to cost of conservation can be summarized as follows:

- The 1974-75 inflation potential will decrease as we approach 1980.
- The current recession and apparent vulnerability of the economy to recessionary forces will gradually vanish over the next two years.
- No severe shortages of manpower or materials and no limitation on the technology for the specified conservation measures will develop between now and 1980.

The relevance of all assumptions and background factors will become more apparent in the discussion of costs and benefits in Sections 2-4.

The discussion of study inputs, background factors, and assumptions has been lengthy because proper evaluations of

conservation is necessarily intricate. The high moral connotation associated with conservation might be sufficient for raising interest, but it is insufficient for determining the proper level of energy cutback or determining the best set of conservation measures to attain a specified cutback. In essence, energy conservation deserves the same painstaking cost/benefit analysis as any other public project. So-called political decisions are possible but, as usual, they are required and justified only because analysts have left a gap by not completing cost/benefit analysis by the time decisions must be made. The analyst might be less equipped than the politician for specifying peoples' choices on the trade-off between present sacrifice and long-run improvements in the availability of energy and better environment, but surely the analyst is in better position to carry out the painstaking calculations that reveal the details in present sacrifice and long-run improvements.

SECTION 2

MACROECONOMIC IMPACT AND OTHER COSTS IN CONSERVATION

Macroeconomic impact is measured by changes in two aggregate indicators:

GNP -- an overall measure of the value of all goods and services produced in the nation or specified region

Price level -- an overall measure of the prices of a given quality and mix of goods and services.

Macroeconomic impact estimates help in providing a complete accounting of all costs from conservation; they include the effects from inter-industry relationships and consumer reactions to reduced incomes which can cause changes beyond the readily observable micro-economic effects; also, they are an average or summary of the countless number of changes in production and prices throughout the economy.

The purpose of this section is to delineate what is included in good measures of macroeconomic impact and to identify other costs in conservation which are important but not included in macro-economic measures. In essence, no analysis of sacrifices from conservation is complete without reliable indicators of macroeconomic impact, yet reliable analysis cannot be confined to macroeconomic effects; on the one hand, macroeconomic impact cannot be measured accurately without first delineating the micro-economic impacts which trigger the macroeconomic changes, on the other hand, there are significant sacrifices from conservation which are not reflected in economic measure of production and, therefore do not register in GNP or price level variables.

The proper measure of total cost of conservation is the dollar value of what people would be willing-to-pay to avoid the losses which conservation brings. Unfortunately, there is no means for asking people what they would pay because they can't foresee more than a minor part of the losses. They cannot, for instance, foresee the many macroeconomic effects which can be triggered by cost increases, resource shortages, and tax increases that can accompany energy conservation. The following is a useful outline of the possible losses from conservation:

1. Consumer surplus from cutbacks in energy normally consumed as final demand.

2. Higher costs of goods and services as a result of replacing energy with more expensive substitutes

3. Lower production of goods and services as a result of

    a. Direct stipulation in conservation
    b. Bottlenecks in production during changes to lower energy usage
    c. Demand falloff as a result of higher prices, loss of jobs, and higher taxes
    d. Multiplier effects initiated by sub-items a-c

4. Adverse income distribution effects as a result of

    a. Unemployment from dislocations of production
    b. Increases in market prices.

In essence, the only significant losses are reductions in consumer surplus but each of the above items is an indication of costs. It is important to note, that other government action such as fiscal and monetary policy can offset or pre-empt the above effects.

Room temperatures and aesthetic automobile design illustrate losses in consumer surplus--Category 1 above. Forcing lower room temperatures is a loss to the extent that the value of foregone comfort exceeds the energy cost. Likewise, an aerodynamic design for automobiles that increases energy efficiency but decreases the aesthetic appeal of automobiles is a loss to the extent of the value of appealing designs, assuming the production cost of the two designs are the same. Neither room comfort nor automobile design are critical to life, but it is presumptuous of an analyst to say that consumers won't or shouldn't be willing to pay for these features. One advantage of the public appeal/information approach in conservation is that each consumer can decide if his sacrifice is justified (see Section 3). Unfortunately, the consumer also needs information on the value of conserving energy and, therefore, the price adjustment approach in which the government ensures that the value of conservation is included in market prices is a preferable implementation mechanism.

Use of solid waste instead of conventional energy is an example of higher costs in Category 2 above. The cost is paid for in tax credit and fast depreciation writeoffs instead of higher prices, but the loss to society is the same. Even the multiplier effect operates as strongly as in higher prices; the tax revenue for offsetting tax credits and depreciation writeoffs lowers the spending power of consumers and, hence, initiates a multiplier effect.

There are many examples of direct and indirect reductions in Category 3--lower production of goods and services. This is one reason why macroeconomic impact is often cited as a primary concern in energy conservation. The first reduction is the lower sales of energy; this would have no significant loss above the consumer surplus in Category 1 if it were not for the fact that it can trigger indirect effects through the economic multiplier. Bottlenecks in supply of critical materials can reduce

production as demands for energy substitutes and material build up with energy cutbacks. The demand side of GNP can create further production cutbacks as higher prices, unemployment, and higher tax payments deter consumers. The economic multiplier adds second and subsequent-round effects whenever there are decreases in consumer incomes or increases in prices.

Since Categories 1-3 represent total losses however distributed, Category 4 represents the added losses from inequitable distribution of losses in Categories 1-3. Cutbacks in economic activity cause unemployment which is a much greater sacrifice for those unemployed than for the average citizen. Likewise, increases in the price level has much greater effect on citizens with fixed or small incomes than on the average citizen.

Realizing that conservation introduces fairly sudden changes in production and consumption, it is best to think of costs in two parts:

1. Short-run (one-time) costs of adjustments in production and consumption, as a new equilibrium is attained.

2. Long-run (continuous) costs.

For example, the use of solid waste as fuel could cause temporary unemployment of workers in energy that waste replaces, but this would only be a short-run effect while workers find new employment. If solid waste is a more expensive fuel than coal, there is a long-run continuous loss equal to the cost difference between coal and waste. The proper evaluation of conservation includes comparing the present value of both short-run and long-run costs with the present value of benefits.

All of the costs/sacrifices in the 4 categories listed on page 20 are estimated as well as available data permits. Summaries are presented along with macroeconomic impact estimates in Section 4.

Whenever study time and research budgets permit, cost estimation should be developed in the format and sequence described above. In fact, the mechanism for implementing conservation should be decided after costs and benefits are estimated. Energy conservation is a policy where it is better to avoid some of the problems in developing reliable cost/benefit estimates by selecting conservation programs where the consumers and producers can make the best decisions by reacting to market prices that reflect true costs. Good econometricians will emphasize that reliable estimates of costs/benefits from public programs are so difficult to develop that policy alternatives should be designed and selected with this perspective in mind. The true criteria for policy and analysis is good policy decisions--decisions that most enhance quality of life.

SECTION 3

QUANTITATIVE MEASURES OF BENEFITS FROM CONSERVATION

The purpose of this section is to identify and quantify the benefits from energy conservation. There is no attempt to entice acceptance of conservation without a complete accounting and a comparison of costs and benefits. However, contrary to general belief, some benefits are subtle to identify and all benefits are difficult to evaluate quantitatively.

The reasons for persistence in quantifying benefits is an obvious one--to reduce errors in selecting the proper level of conservation and selecting the best mix of conservation measures for attaining a specified level. One apparent reason for shrouding conservation with a moral cloak is to avoid a natural bias in more rigerous analysis--a bias that results because the cost/sacrifices of conservation are immediate and readily apparent while the benefits are long-term and less readily apparent. For example, it was hard for decision makers in timber harvest and dam construction in past decades to foresee the 1960's rise in outdoor recreation and, consequently, the higher value on access to wilderness and virgin forests. The sacrifice in foregoing prime timber and cheap water at the time of harvest and dam construction were more obvious. When measuring willingness-to-pay for energy conservation benefits we should include a realistic appraisal of unforeseen future uses of present resources; a realistic appraisal does not justify all proposed conservation nor does it assign zero value to future benefits that are difficult to foresee accurately. In essence, willingness-to-pay should, and must, include gambles. Neither the analyst nor the policy maker

can eliminate basic uncertainties, but they can develop the best decision rules for operating within the basic uncertainties.

All of the benefits listed in Table 1 and discussed earlier should be evaluated in terms of willingness-to-pay for the following effects of conservation:

1. Reduced pollution--What is the public willing to pay for the net reduction in pollution that reduced energy use (particularly domestically produced energy) will bring?

2. Slower depletion of present energy--What would future energy users be willing to pay for claims on present energy given the presently assessed probabilities of having to use more expensive (or cheaper) energy when present energy is depleted?

3. Reduced embargo/monopoly vulnerability--What should the public be willing to pay to lower the probability of embargos and price increases and avoid the more severe consequences when they do occur?

4. Fewer inefficient energy users--The relevant question is obvious in this case: What is the dollar savings from removing the inefficiencies?

Since willingness-to-pay is in reference to persons in different years (even different generations) answers to each of the above questions should be converted to present value (or equivalent annual benefits). This is particularly obvious in the second category--slower depletion of present energy. The

cost of conserving present energy is borne by present consumers but the benefits are enjoyed by consumers in future years--those periods when the energy being saved now can be used instead of the more expensive energy that will replace present energy (possibly nuclear fusion and solar energy). The energy conservation analyst shouldn't (and doesn't have to) decide what favors the present generation should do for later generations, but he is the best equipped to carry out the intricate calculations involving probabilities, cost differences, and present value interpretation.

The following sections indicate how willingness-to-pay questions can be transformed into equivalent questions that are easier to answer; they also provide ball-park estimates of numerical values for each type of benefit from energy conservation.

REDUCED POLLUTION

The value of pollution reduction via energy conservation is either (1) avoiding the cost of pollution control on energy production and use--the energy eliminated by conservation--or (2) reducing the damage to quality of life from pollution beyond that eliminated by pollution control. For an objective analysis, pollution from all phases of the energy cycle must be included: the extraction phase as in strip mining disruption, the transportation and conversion phase as in sulfur emissions from power generation and the end use phase as in automobile exhaust.

In previous research (Ref. 16), Jack Faucett Associates has ascertained through interviews and literature review the following ball-park estimates:

Reasonable pollution control will increase total energy costs about 10 percent, up to distribution;[1] this does not include end use such as automobile emission control.

Pollution from energy production and use is distributed approximately[2]

5 percent land and landscape
30 percent water
60 percent air
5 percent worker comfort and health

With pollution control that is feasible at a 10 percent increase in energy costs, the environmental degradation can be reduced[2]

55 percent in land and landscape
50 percent in water
80 percent in air
50 percent in worker comfort and health

These estimates plus some related assumptions allow the following first approximations on the value of reduced pollution from energy conservation in 1980:

$1.4 billion reduction in pollution control costs as a result of lower energy usage

$ .6 billion in reduced environmental damage beyond the expected pollution control on energy actually used.

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[1] *The 10 percent is a concensus of opinions of persons contacted by Jack Faucett Associates.*

[2] *These estimates are based on opinions of persons contacted by Jack Faucett Associates and the assumption that the cost of proposed controls are proportional to the damage from present pollution levels.*

Details on this calculation are given in Appendix B. The estimated $1.4 billion benefits constitute approximately 1 percent of the expected $150 billion energy sales in 1980. These estimates mean that society should be willing to pay $2.0 billion/year (1.4 ÷ 6) as of 1980 to avoid the pollution from the extra energy that would be consumed without the specified conservation measures.

SLOWER DEPLETION OF PRESENT ENERGY

The benefit to future energy users is the expected difference between the cost of producing present energy and the cost of the best substitute as of the time of production; the benefit to present users is fulfilling their obligation to future users--the same users at a later date or different users in future generations. Fortunately, the difficult problem of assessing obligation can be transformed into a simpler problem that can be evaluated quantitatively.

There are two basic ways to help future energy users: (1) save present energy under the assumption that it will be a cheaper resource than available substitutes in later years; and (2) fund alternative investments now and assign the proceeds to pay for any higher cost of energy that will be used in later years. Conserving present energy--e.g., leaving more crude oil in the ground--is an investment which will hopefully have high returns in the future; likewise, funds can be invested in banks, recreation areas, medical research and countless other ways which can have high returns in future years. The value of conserving energy cannot exceed the cost of alternative investments with equal or greater expected value for future citizens, otherwise the alternatives are better than energy conservation. Whether or not we tax

the future citizens or present a gift of either cheap energy or returns from alternative investments is a question outside the scope of this report.

By using the "cost of capital" as the return on alternative investments that can help future generations, we can quantify the value of energy conservation. This quantification can be designated as the opportunity cost of energy consumption because it is the cost of foregoing the opportunity to use the energy in later years. There are three essential parameters--(1) the cost difference between the energy being conserved and the best available substitute in future years, (2) the time at which the conserved energy will be produced and used, and (3) the discount for computing present value.

The following hypothetical example illustrates the parameters and the mathematics:

conserve 1 barrel of oil in 1974

postulate that the 1 barrel of oil will be used in 1990 instead of shale--the best substitute as of that point

estimate production costs of $6.00 and $12.00 for the 1 barrel from presently used oil reserves and from shale as of 1990

specify an annual discount factor of 10 percent (the rate specified for cost/benefit analysis of public investments)

calculate the benefit of conservation as

$$\text{opp. cost} = \left[\frac{1}{1 + .1}\right]^{16} [\$12.00 - \$6.00] = \$1.68$$

This particular benefit from conservation--i.e., the benefit pertaining to delaying the use of more costly energy--is the opportunity cost of $1.68 in this example. In other words, if the 1990 energy user could participate in today's market he would bid $1.68 to keep a barrel of oil in the ground for use in 1990.

The procedure for calculating opportunity cost in the real world context is complex because of the great number of substitutions among different energies in each of the user categories. The two publicly available estimates of opportunity costs [Ref. 14 and 16] were developed by using linear programming to allocate energy among users and among time periods.

Estimates of opportunity cost developed by Jack Faucett Associates were expressed in percent of production cost to avoid the complex problem of monopoly pricing and embargos which are considered in the third category of benefits from conservation--reducing embargo/monopoly vulnerability. The opportunity cost estimates are summarized below [Ref. 16]:

Crude Oil	22 percent of wellhead cost
Natural gas	32 percent of wellhead cost
Uranium	10 percent of wellhead cost
Coal	Negligible[1]
Oil Shale	Negligible

This means, for example, that the market price of crude oil should include an additional 22 percent of production cost which is approximately 22 percent of $2.00 or $.44/barrel at present costs of domestic oil production. This also means that the

[1] *The limited quantities of low-sulfur coal near the point of consumption are an exception in that opportunity cost could be 10 percent of minehead cost.*

value of conserving oil is $.44/barrel saved. More interpretation of the above estimates is given in the summary of cost/benefits at the end of this section.

REDUCED EMBARGO/MONOPOLY VULNERABILITY

The Arab oil embargo in 1973 and the current $11.00/barrel monopoly price on imports illustrate situations in which energy conservation could be helpful. Reducing demand for petroleum can (1) reduce the probability of embargos and monopoly pricing and (2) reduce the economic impact if embargos or monopoly pricing occur.

The reasoning behind the hypothesis that conservation will reduce the probability of embargos/monopoy pricing is as follows: reduced import demand will cause pressure among exporters in the effort of each country to sell its own oil; the evidence that the United States can implement effective conservation will convince exporting countries that demand is elastic and, therefore, monopoly pricing is not as attractive; the combined effect of greater supply pressure and greater demand elasticity will effect decisions on embargos and monopoly pricing.

The reasoning behind the hypothesis that conservation will reduce the economic impact of embargos and monopoly pricing is fairly obvious: the lower the imports the less disruption import cutoffs or import price increases can have on the U.S. economy.

The best available estimate of the value of reducing impact of embargos/monopoly pricing through oil consumption is $.60/barrel. Our estimate of the value/barrel of a permanent reduction in demand includes the 60¢ and an additional factor for reduced probability of embargos:

$.60/barrel for reduced impact
$.15/barrel for reduced probability of embargo
$.75/barrel total value

In the price adjustment approach to conservation, a $.75/barrel tariff should be added to the market price. There is no need for the market price of all oil to include the $.75, however.

In essence, the 60¢/barrel is a tax sufficient for covering the losses from an embargo if and when they occur. The reason that a long-run tax is more efficient is that it influences demand under a relatively elastic long-run demand schedule whereas the embargo causes losses under a relatively inelastic short-run demand schedule.

FEWER INEFFICIENT ENERGY USES

The discrepancies and lack of detail among the many studies on energy efficiency do not allow precise estimates of what consumers should be willing to pay to remove inefficiencies. However, a hypothetical example and some reasonable assumptions will allow us to illustrate this fourth category of benefits from energy conservation.

If the energy usage of an appliance can be reduced 20 percent with a 10 percent increase in appliance cost, and if the annual energy cost is 15 percent of the appliance cost in each year of a 12-year life, the net benefit expressed as a percentage of energy cost is

$$\text{Benefit} = \frac{.20[.15] - .10[12]}{.15} = 12 \text{ percent of original energy cost}$$

In other words, the benefit is the energy savings (20 percent of .15 of the appliance cost)minus the annualized increase

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in appliance cost (10 percent increase at a 12 percent ammortization) divided by the original energy cost (15 percent of the appliance cost).

The above example indicates the intricate calculation that must be made for each appliance. We can get some feel for the net value of the pre-selected conservation measures by assuming that improving energy efficiency at present energy prices would merely allow the consumer to break even--i.e., the annualized extra appliance cost would equal the annual savings in energy cost--but there is a saving if prices are too low.

The value for conservation is the difference between present energy prices and the new total social cost of energy when benefits in categories 1-3 are included. Using the best general estimates of categories 1-3, and the above assumption, we can develop an estimate of the benefit from removing inefficiencies:

2 percent of energy cost for reducing pollution (see the first sub-section of this chapter)

7 percent of energy cost for delaying energy depletion (weighted average of estimates in the second sub-section)

3 percent of energy cost for reducing vulnerability (based on $.75/barrel savings, 1/4 of the electricity is from oil, and the price of oil for power generators is $6 /barrel)

12 percent total;

For every dollar of energy saved through reduced energy usage in, say, appliances, the net value to society is $.12. This is the difference between the lower cost of energy and greater cost of the appliance.[1]

[1] *This estimate is not equal to the market value of fuel saved. The latter is a gross saving whereas the true benefit is only net savings.*

SUMMARY OF ALL BENEFITS

Since the preceding estimates are expressed in terms of the value per relevant unit of energy, it is necessary to apply these units to the energy savings in the eight specified conservation measures for 1980. The best available estimates are as follows:

$.02/MBTUs	for pollution reduction. This applies to all of the 5.9×10^{15} BTUs saved in all 8 pre-selected conservation measures.
$.11/MBTUs	for slower energy depletion. This also applies to the 5.9×10^{15} BTUs saved in all 8 measures
$.14/MBTUs	for reducing vulnerability. This applies to 5.1×10^{15} BTUs saved in conservation measures C and E and 30 percent of conservation measures B, F, G, and H.
$.28/MBTUs	for eliminating inefficient energy use. This applies only to 1.3×10^{15} BTUs saved in conservation measure F.

The reader should note that the savings per MBTU are tied specifically to the package of eight pre-selected conservation measures; the reliability of estimates is limited by the quality of input data and assumptions that were necessary.

This section presents a methodology and presents a first approximation of quantifications that are essential for proper analysis of conservation. If this type of analysis is undertaken for policy review, we can expect better determination of optimum levels of conservation and optimum combination of alternative conservation measures.

SECTION 4

BEST ESTIMATES OF MACRO-ECONOMIC EFFECTS: 1980

The best estimate of probable reduction in GNP caused by lower energy consumption from the set of eight conservation measures is presented in this section. The conservation measures are assumed to begin in early 1975, in order to reach the specified energy savings by 1980. The macroeconomic impacts discussed in this section include impact on GNP as well as effects of potential price level changes.

Table 3 indicates a 1.4 percent reduction in GNP in 1980[1] produced by various repercussions from the eight conservation measures. The three significant factors that can initiate this impact are:

1. Direct cuts in final demand-- the direct effect of cutbacks in energy and other products; examples include lower gasoline consumption with auto design changes and reduced home heating with thermostat changes.[2]

2. Supply bottlenecks--restriction on the factors of production (e.g., the availability of technology or machinery for implementing solid waste as fuel in power generation).

3. Demand falloff--market response to price increases or income reduction

[1] *A reduction in GNP from 1.060 to 1.040 trillion in 1958 dollars.*

[2] *Cuts in final demand are direct and final; it is not appropriate to evaluate these cuts in an input-output or a simultaneous equations model.*

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It is the interaction of these elements (e.g., a simultaneous demand falloff and a supply bottleneck) in relation to the vulnerability of the economy that determines the macroeconomic impact. Analysis of this interaction can frequently indicate the changes in level and timing of conservation measures that may significantly reduce the amount of impact. It has been assumed in this effort that there are no extenuating circumstances beyond the current inflation and recession that make the economy particularly vulnerable to recessionary forces as these conservation measure are implemented.

The direct reduction in energy sales is a function of the amount of energy saved, relative to normal energy sales, and the ratio of marginal to average cost per unit of energy (BTU). Energy sales will be reduced $70 billion or .5% of the 1980 GNP[1] assuming implementation of these conservation measures as outlined in Section 1 and Appendix A. The total energy bill is estimated to be ten percent of the GNP in 1980. This is slightly higher than the present ratio to account for increasing energy costs. The relative shares of energy by sector are presented in Table C.1.

There are no significant bottlenecks in the proposed conservation scheme; the eight conservation measures were pre-selected under a criterion that they no create restrictions on production and supply of goods and services. The amount of new materials, as well as present technology and future research and development required, were considered in determining feasible energy savings in order to avoid bottlenecks [Ref. 7].

[1] *No estimate of normal inflation was made for this report, but the estimated 1.064 trillion GNP in 1958 dollars could be $1.4 trillion in 1980 dollars.*

TABLE 3.-REDUCTION IN GNP FROM CONSERVATION MEASURES: 1980[a]

	1980 % Reduction
Energy Sales	0.5
Bottlenecks in Production	0.0
Demand Responses	0.4
Multiplier Effect	0.5
Total Reduction in GNP	1.4[b]

[a] *See Appendix C for specific calculation of the conservation impact on GNP.*

[b] *The estimated 1.4% reduction in the projected 1.016 trillion 1920 GNP could be mitigated by federal tax reduction, fiscal policy and monetary policy.*

If the suggested conservation measures would have required a higher consumer cost for the same utility, the elasticity of demand would cause a reaction to cost increases. The .4 percent fall-off in demand shown in Table 3 is the product of a weighted average cost factor and the demand elasticity for each sector, and applied to total energy sales. In order to determine the appropriate cost factors for this analysis, vectors of the input-output model were searched to determine areas within each sector that will be most susceptible to cost increases.[1] The input-output system provides a good framework for the measurement and analysis of economic interrelations among industries. The use of input-output analysis can be particularly helpful in estimating direct, or first-round, effects by indicating the relative input required for each dollar of production. Indirect effects must then be calculated to summarize any repercussions and permit re-evaluation of the requirements needed to satisfy changes in final demand. Because of the limitations of this present effort, input-output analysis was limited to the largest energy coefficients and the use of structural multipliers to determine the amount of impact on residential, commercial, industrial and transportation sectors.[2]

An income multiplier has been applied to the sum of the above effects since additional consequences can be generated by reduced income of consumers. The factor of .5 was calculated from a 1.5

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[1] *The Input-Output Structure of the U.S. Economy: 1967, Table 2.*

[2] *A multiplier is the ratio of "direct + indirect" effects to direct effects; the ratio of the coefficient in the inverse matrix to the coefficient in the direct requirements matrix.*

multiplier in 1980[1], when adjustments have had an opportunity to be incorporated during the first 5 years of implementation. The nature of the conservation scheme minimizes the multiplier effect because it allows only a small strain on the economy and enough time to recognize any weaknesses that might otherwise increase the macro-economic impacts.

Figure 3 shows the trend in the energy/GNP ratio given the estimated GNP reduction in Table 3. The ratio is the BTUs specified by the conservation scheme divided by the appropriate GNP.

In addition to the macro-economic effects measured by the expected changes in GNP presented above, we must be concerned about possible price level changes. Inflation, as of 1975, is severe and even small increments in inflationary pressure between now and 1980 could be burdensome.

Referring to the classification of conservation measures in Table 2, reasons for price level changes are fairly easily identified:

1. Higher production costs in meeting government specified energy usage standards in the implementation of conservation measures C_1 and F
2. The price adjustments for implementing conservation measures A, B, D and E
3. The extra consumer costs in the voluntary engine tune-ups in conservation measure C_2
4. Changes in the spending power (real income) of consumers as a result of tax increases and price adjustments

[1] *1.5 is a reasonable estimate given the warning on energy conservation and the possibility of spending money from energy saving on other products.*

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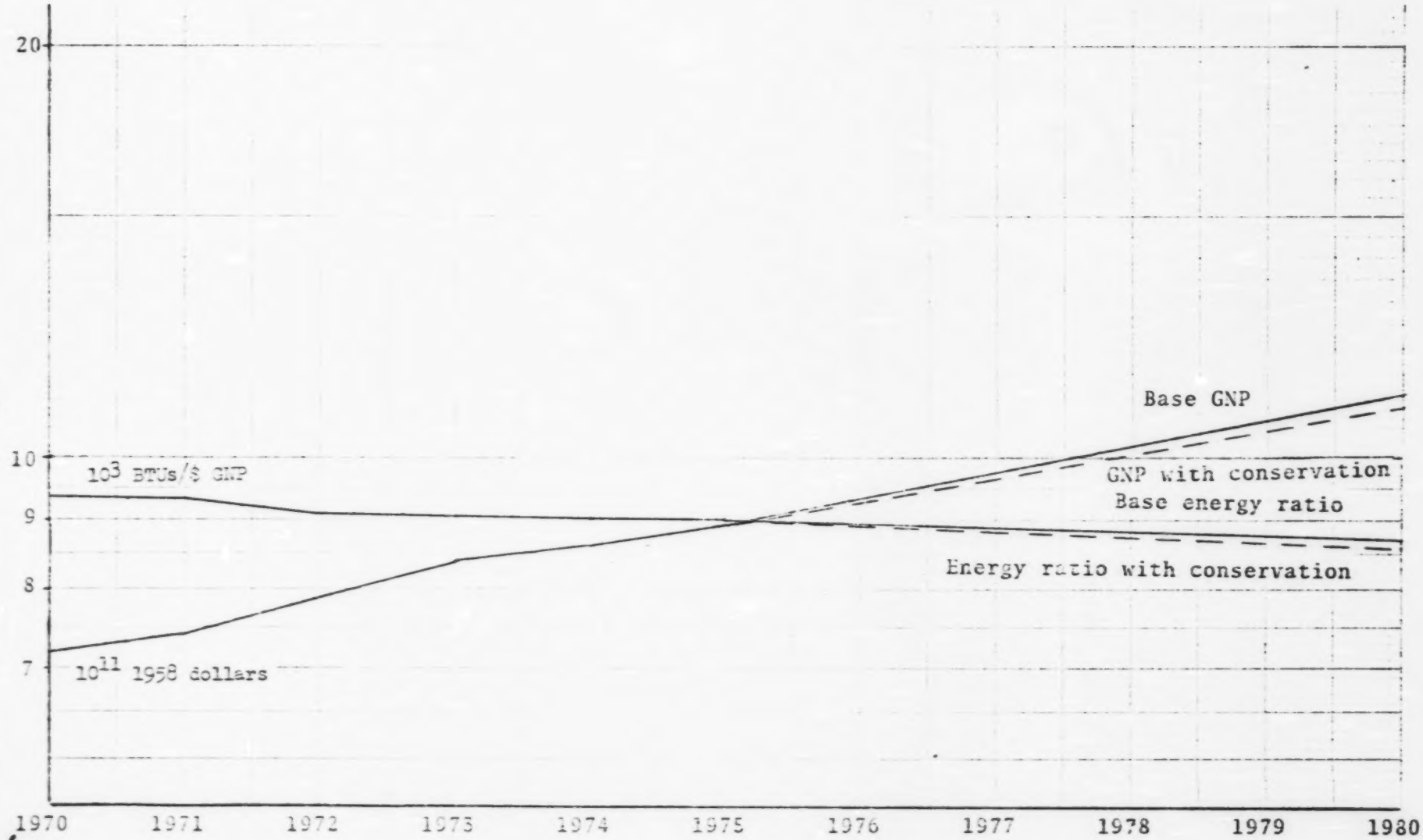

FIGURE 3.-ENERGY/GNP TREND WITH EIGHT CONSERVATION MEASURES

The energy conservation from changing thermostat settings in Measures G and H will not generate any inflationary pressure, but could exert deflationary pressure by the reduced demand for energy.

In summary, it appears that the pre-selected set of conservation measures will be more deflationary than inflationary. There are three main reasons: first, most of the conservation measures are implemented through government subsidies which means that consumers income will be decreased as a result of the higher taxes necessary in paying for the subsidies; second, since more than two-thirds of the conservation is based on voluntary compliance, it is unlikely that implementation will take place if costs are higher with than without conservation; and third, the reduced energy usage can defuse the pressure for price increase within the energy sector--a key inflationary element in 1974.

Besides increasing costs directly, there is only one other significant source of inflation--bottlenecks in resources as conservation is implemented. The study inputs include verification that the rates of required changes for conservation should cause no problems in goods and services necessary for the changes to less energy use. Furthermore, the voluntary nature of most conservation allows postponement of implementation if any bottlenecks should occur.

In one sense, the absence of inflationary forces is bought at the price of reduced production of goods and services. The 1.4% reduction in GNP discussed above seems small, but it might be even less if the 5.9% reduction in energy were obtained differently. However, the major point throughout this report is that energy conservation should be selected after analyzing both costs (macro-

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economic impact and other) and benefits for various levels of energy cutback and various mixes of conservation measures.

The distribution of economic impacts from conservation among the population does not seem to constitute a significant problem except for the obvious hardships in selected unemployment. The estimated 1.4% reduction in GNP will probably spread among most geographic regions and economic sectors. If GNP is reduced 1.4%, employment will reduce slightly less, say, 1.2 to 1.4%, causing unemployment to increase from the typical 4.5 to 5.7%. The specific individuals caught in the extra unemployment will surely suffer from an inequitable sharing of burden. Unfortunately, there is no way to identify them specifically until they arrive at the unemployment compensation office. Any changes in conservation that reduce the expected GNP reduction can, of course, reduce the inequities in the accompanying unemployment.

APPENDIX A

ENERGY SAVINGS AND SELECTED DIRECT IMPACTS

The major inputs to this study are summarized in Table A.1., with details in Table A.2. These inputs are results from a major study on maximum possible energy savings from various conservation programs, as qualified by a second study which evaluated technical, economic, and political feasibility of each conservation measure (Refs. 7 and 17).

The eight specific conservation measures listed in Table A.2 are expected to produce the energy reductions shown in Table A.1. They will reduce total energy in 1980 by 5.9 percent; i.e., expected energy consumption will be 5.9 percent less than it would be without government-sponsored energy conservation.

Although the eight conservation measures are generally independent, the expected saving would be reduced if a large number of other conservation programs were also enforced. In other words, as energy cutbacks exceed 5-8 percent of normal energy consumption, the effectiveness of an additional conservation program will obviously be less than if it were the only conservation program.

The eight conservation measures were selected prior to the analysis described in this report. They were selected because (1) they constitute an interesting set of fairly complementary programs, (2) they require cutbacks in each of the four economic sectors, as shown in Table A.1., and (3) they involve a mix of implementation approaches, as indicated in the first part of Table A.1.

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Further details on the specific conservation measures are available in recent reports to the Environmental Protection Agency by Mathematica and Peat, Marwick, Mitchell and Company (Refs. 7 and 17).

TABLE A.1.—PERCENT DECREASE IN TOTAL ENERGY USE: 1980

	Estimated Savings[a] (10^{15} BTUs)	Baseline Consumption[b] (10^{15} BTUs)	Savings as % of Normal Energy Use
Residential	2.30	20.88	11.0
Commercial	1.06	14.57	7.3
Industrial	.40	38.93	1.0
Transportation	2.14	25.27	8.5
Total Uses	5.90	99.65	5.9

[a] *Feasible savings from eight conservation measures as estimated by Peat, Marwick, Mitchell and Company. See Table A.2.*

[b] *From working tables obtained from Peat, Marwick, Mitchell and Company, May 1974, and March 1975. These tables were specified as official input for the JFA study discussed in this report.*

TABLE A.2.-EIGHT SPECIFIC CONSERVATION MEASURES[a]

A. Use Solid Waste as Fuel in Power Generation

Direct combustion of solid waste (as a mixed charge with fossil fuel) would be encouraged by economic incentives--tax credit on investment and above-normal depreciation rates.

	Annual Impact				Cumulative Impact
	1977	1985	1995	2000	
A. Energy Savings (BTUs x 10^{12})					
1. Maximum	54.4	96.7	447	759	4,602
2. Estimated Feasible	54.4	96.7	447	759	4,602
B. Impacts (Millions of Dollars)					
1. Private Industry Electric Industry	$92m	$162m	$751m	$1,276m	$8,405m
2. Private Consumer Savings	$18.9m	$32.2m	$150m	$255m	$1,681m
3. Public Sector Government Balance of Payments	NOT ESTIMATED NOT APPLICABLE				
4. Employment (Jobs)	INSUFFICIENT DATA				
5. Environment (Percent Reduction) Particulate Emissions	Increase - Not Estimated				
Solid Waste Reduction	2.1%	3.8%	27.4%	30.0%	

[a] *Information was obtained from a draft of a report to be submitted by Peat, Marwick, Mitchell and Company to the Environmental Protection Agency.*

TABLE A.2.-EIGHT SPECIFIC CONSERVATION MEASURES (continued)

B. Recover and Use Waste Heat in Power Generation

Recovery of waste heat in power generation will be encouraged by the same incentives as in A.

	Annual Impact				Cumulative Impact
	1977	1980	1985	1990	
A. Energy Savings (BTUs x 10^{12})					
1. Maximum	0	1,491	4,496	7,451	47,547
2. Estimated Feasible	0	1,491	4,496	7,451	47,547
B. Impacts (Millions of Dollars)					
1. Private Industry					
Power plant revenues from sale of steam		$3,019m	$9,487m	$16,747m	$100,327m
Annualized Capital Cost of Power Plants	0	($2,046m)	($6,430m)	($10,603m)	($70,479m)
Added Operating Cost			Insufficient Data		
2. Private Consumer			Not Applicable		
3. Public Sector					
Government	0		Not Estimated		
Balance of Payments	0	$39.6m	$124.5m	$206.4m	$1,317m
4. Employment (Jobs)			Insufficient Data		
5. Environment					
Thermal Pollution (BTUx10^{12}) Reduced	0	1,491	4,496	7,451	
SO_2 Emissions (Percent Reduction)	0	2.8%	8.2%	13.2%	

* Assumes added operating costs equivalent to fuel costs avoided.

TABLE A.2.-EIGHT SPECIFIC CONSERVATION MEASURES (continued)

C. Improve Gasoline Efficiency of Automobiles

Lower gasoline consumption will result from voluntary engine tune-ups and mandatory changes: (1) use of radial tires, (2) more energy efficient aerodynamic vehicle design, and (3) variable transmissions.

	Annual Impact				Cumulative Impact
	1977	1980	1985	1990	
A. Energy Savings (BTUs x 10^{12})					
1. Maximum	1175	1895	2830	3404	33,688
2. Estimated Feasible	0	1690	2700	3484	31,089
B. Impacts (Millions of Dollars)					
1. Private Industry	Insufficient Data				
2. Private Consumer Savings	0	$7903 m.	$11203 m.	$13993 m.	$125,728 m.
3. Public Sector					
Government Tax Loss	0	($1592 m.)	($2257 m.)	($2799 m.)	($25146 m.)
Balance of Payments	0	$ 541 m.	$ 893 m.	$1107 m.	$ 9946 m.
4. Employment (Jobs)	Insufficient Data				
5. Environment (Percent Reduction)	Not estimated (see text).				

TABLE A.2.-EIGHT SPECIFIC CONSERVATION MEASURES (continued)

D. Recycle Materials for Which Original Production Is Energy Intensive

Recycling of materials like aluminum would be encouraged by government subsidies for defraying cost of scrap collection and salvage, resulting in energy saving by lowering the use of energy-intensive raw materials.

	Annual Impact 1977	1980	1985	2000	Cumulative Impact
A. Energy Savings (BTUs x 10^{12})					
1. Maximum	155	293	354	420	4,668
2. Estimated Feasible	2.6	14.7	97.4	214.0	1,093
B. Impacts (Millions of Dollars)					
1. Private Industry					
Recycling Capital Costs		Not Estimated			
Industry Savings	$3.3m	$19m	$126m	$279m	$1,418m
2. Private Consumer Savings	NOT APPLICABLE				
3. Public Sector					
Government	($11m)	($63m)	($417m)	($963m)	($4,680m)
Balance of Payments 1/	$ 0.2m	$ 1.4m	$ 8.1m	$17.9m	$ 91.0m
4. Employment (Jobs)					
Primary Material Industries	NOT ESTIMATED				
5. Environment (Percent Reduction)					
Particulates Reduction	.01%	.03%	.20%	.42%	
Solid Waste Reduction	.07%	.20%	1.39%	4.0%	

1/ Does not include steel and copper

TABLE A.2.-EIGHT SPECIFIC CONSERVATION MEASURES (continued)

E. Increase Bus Transit Relative to Automobile

Increased use of transit would be encouraged by parking tax to discourage automobile use and subsidies to lower bus fares and defray costs of expanded bus service--greater frequency/area coverage, improved routing, and exclusive bus lanes.

	Annual Impact				Cumulative Impact
	1977	1980	1985	1995	
A. Energy Savings (BTUs x 10^{12})					
1. Maximum	121	248	424	575	5035
2. Estimated Feasible	121	248	414	575	5033
B. Impacts (Millions of Dollars)					
1. Private Industry					
Bus Manufacturing	$ 350 m.	$ 350 m.	$ 350 m.	$ 350 m.	$ 4,900 m.
Bus Transit Added Revenues	$ 957 m.	$2001 m.	$3335 m.	$4629 m.	$ 40,477 m.
Bus Transit Annualized Capital cost	($ 46 m.)	($ 184 m.)	($ 414 m.)	($ 644 m.)	($ 4830 m.)
2. Private Consumer Savings	$ 198 m.	$ 414 m.	$ 690 m.	$ 958 m.	$ 8379 m.
3. Public Sector					
Government fare box subsidy	($ 239 m.)	($ 500 m.)	($ 834 m.)	($ 1157 m.)	($ 10,119 m.)
Balance of Payments	$ 38 m.	$ 79 m.	$ 133 m.	$ 184 m.	$ 1,607 m.
Gasoline Tax Loss	($ 98 m.)	($ 200 m.)	($ 335 m.)	(465 m.)	($ 4,044 m.)
4. Employment (Jobs)					
Bus Manufacturing	18400	18400	18400	18400	18400
Bus Transit	68400	149000	238200	330600	330600
5. Environment (Percent Reduction)					
CO Reduction	.051%	.121%	.408%	.605%	
HC Reduction	.032%	.083%	.100%	.164%	

TABLE A.2.-EIGHT SPECIFIC CONSERVATION MEASURES (continued)

F. Establish Minimum Energy Efficiency for Appliances

Lower energy consumption in appliances would be forced by regulations on minimum energy efficiency.

	Annual Impact				Cumulative Impact
	1977	1980	1985	1990	
A. Energy Savings (BTUs x 10^{12})					
1. Maximum	865	1,348	2,221	2,863	23,268
2. Estimated Feasible	865	1,348	2,221	2,863	23,268
B. Impacts (Millions of Dollars)					
1. Private Industry					
Appliance Industry		Insufficient Data			
2. Private Consumer Savings	$3,591m	$6,470m	$13,016m	$16,749m	$148,323m
3. Public Sector					
Government		Insufficient Data			
Balance of Payments	$ 68m	$115m	$196m	$234m	$2,272m
4. Employment (Jobs)					
Appliance Industry		Insufficient Data			
5. Environment (Percent Reduction)					
SO_2 Reduction	2.4%	2.6%	3.3%	2.7%	

TABLE A.2.-EIGHT SPECIFIC CONSERVATION MEASURES (continued)

G. Change Residential Thermostat Settings

Lower energy use for home heating and airconditioning would be encouraged by public appeals for changing thermostat settings.

	Annual Impact 1977	1980	1985	1990	Cumulative Impact
A. Energy Savings (BTUs x 10^{12})					
1. Maximum	895	967	1,079	1,195	14,643
2. Estimated Feasible	537	583	647	717	8,788
B. Impacts (Millions of Dollars)					
1. Private Industry	No Significant Impacts				
2. Private Consumer Savings	$ 1,568	$ 1,690	$ 1,873	$ 2,073	$ 25,512
3. Public Sector					
Government	($0.1m)	($0.1m)	($0.1m)	($0.1m)	($1.4m)
Balance of Payments	$84m	$90m	$66m	$72m	$879m
4. Employment (Jobs)	No Significant Impacts				
5. Environment (Percent Reduction)					
SO_2 Reduction	.14	.14	.12	.11	

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TABLE A.2.-EIGHT SPECIFIC CONSERVATION MEASURES (continued)

H. Change Commercial Building Thermostat Settings

Lower energy use for heating and cooling commercial buildings would be encouraged by public appeals for changing thermostat settings.

	Annual Impact				Cumulative Impact
	1977	1980	1985	1990	
A. Energy Savings (BTUs x 10^{14})					
1. Maximum	1,000	1,139	1,448	1,667	18,732
2. Estimated Feasible	600	683	841	1,000	11,143
B. Impacts (Millions of Dollars)					
1. Private Industry Commercial Building Owners/Operators	$ 2,884m	$ 3,283m	$ 4,042m	$ 4,807m	$ 53,582m
2. Private Consumer		Not Estimated			
3. Public Sector Government	($0.1m)	($0.1m)	($0.1m)	($0.1m)	($.14m)
Balance of Payments	$ 62m	$ 71m	$ 87m	$ 104m	$ 1,159m
4. Employment (Jobs)		Insufficient Data			
5. Environment (Percent Reduction) SO_2 Reduction	.15%	.17%	.16%	.17%	

APPENDIX B

TECHNICAL EVALUATION OF ENVIRONMENTAL GAINS AND OTHER BENEFITS

The purpose of this appendix is to provide a more general methodology for evaluating environmental benefits from energy conservation and present more details on the calculation of benefits presented in Section 3. The reader should note that the entire philosophy on benefits presented in this report contrasts sharply with a commonly accepted attitude that conservation is definitely justified and that analysis should be confined to finding least-cost conservation. Without first accepting the need to quantify and sum diverse benefits from conservation, this appendix will have little meaning.

Conservation of energy is an explicit effort to modify the normal operation of the market mechanism even though good markets are generally accepted as the best means for determining prices and allocating resources. The objective is to lower the rate of consumption in order to attain greater welfare over the long-run. Everyone agrees that cutback in consumption will involve immediate sacrifices, but there is much disagreement in establishing the level and type of cutbacks for which short-run sacrifices are justified by long-run gains.

A framework for evaluating energy conservation must include three basic components:

1. The basic mechanism for implementing conservation
2. The expected benefits from conservation
3. The expected costs, including personal sacrifices and economic repercussions from energy cutbacks.

Analysis of energy conservation can start with any one of the three components, but all must be considered in designing optimum

conservation. The pre-selected conservation measures were accepted as inputs for this study and, therefore, no discussion of implementation mechanism is provided. Details on the pre-selected implementation are given in Appendix A.

Benefits from conservation are difficult to identify and even more difficult to quantify. For purposes of this report, there are four major benefits:

1. Conservation of energy will reduce environmental degradation, the cost of which is not reflected adequately in energy prices.
2. Conservation of present energy will delay the point at which more expensive energy must be used as resources of present energy become depleted.
3. Reducing demand toward the level of domestic production will reduce our vulnerability to foreign oil embargos and monopoly pricing.
4. Conservation of energy in prescribed ways can eliminate the wastes that occur in the uses where externalities and small inefficiencies are normally overlooked unless the government provides specific guidance and incentive for user conservation.

Each of these benefits is very difficult to evaluate, even for analysts with extensive research budgets. The individual consumer probably has the best information on his cost (sacrifice) from conservation, but he doesn't have means to determine the sum of benefits in the above four categories; officials who promote conservation should be responsible for determining if the above benefits justify costs of conservation.

It is helpful to analyze each of the major reasons for conservation in order to gain better perspective on the possible costs of and benefits from attaining various levels and types of conservation. The first benefit from conservation--reduced pollution and pollution control costs--is the most illustrative of the important differences between level of energy cutback and type of energy cutback. It is not obvious that all conservation will provide a net gain in environmental quality. For example, if the cost of sacrifice in energy conservation is, say, $1.00, and the cost of the same amount of pollution control by direct means is less than $1.00, the conservation cannot obviously be justified in environmental benefits alone. This possibility seems quite plausible when the proper perspective is developed: since conservation cannot eliminate a large percent of energy use, we must install environmental protection equipment in addition to conservation; since the marginal cost of pollution control for additional energy can be small once the control process is developed and installed, the net contribution of energy conservation to pollution control may be small in some instances.

If, however, energy conservation can be focused on those fuels and those regions which have greatest need for pollution control, the environmental benefits can be extensive. Some specific examples of desirable pinpointed conservation are 1) energy cutbacks in the near future before pollution control is fully developed as in the case of used autos, 2) energy cutbacks in large cities where pollution is particularly bad, and 3) cutbacks in those forms of energy where environmental dangers will linger long after energy is consumed as in the case of radio-active wastes and acid mine drainage.

The second benefit from conservation--slower energy depletion--should be re-interpreted in order to reduce the difficulty of questions that must be answered. For example, instead of asking

what the present generation owes the next generation in preserving cheap energy, we should ask what the best means of helping is, given we want to help. Besides energy conservation, the next generation, so to speak, can be helped by investing amounts equal to the sacrifice in reducing present energy consumption; this equivalent investment should be done in ways that will be most helpful, including pollution control. In other words, present society should be indifferent between sacrifice of X dollars from conservation and X dollars of outlays in investments in other areas that will benefit future generations.

Since fossil fuels--the predominant energy at present--are like a savings account with zero or negligible interest rates (negligible expansion of supply), the resources will be depleted with continued use, only the timing can change. It makes sense to draw down a savings account, but only at rates that will preserve sufficient reserves to last until a renewable energy is available. Since there is no hope of fossil fuels lasting forever, the question is how best to ensure that availability of present energy and new energy overlap. On the one hand, we can conserve present energy and, on the other hand, we can invest amounts equal to the sacrifice in conservation for developing new energy. Once we realize that renewable energy must arrive someday, we can see that greater investment in energy development is a possible alternative to conservation for the second benefit--slower energy depletion.

The third benefit of conservation--reduced vulnerability to foreign embargos and monopoly pricing by reducing demand--appears to be the main impetus for project independence. It is a legitimate goal, but also one that can be obtained in other ways, including storage, increased supply, and emergency plans. To obtain maximum benefit, conservation must be focused on uses of petroleum and close substitutes, since foreign embargos are significant only in petroleum. Effective conservation for reducing vulnerability must be pinpointed as sharply as conservation for environmental improvement. Unfortunately, the most effective conservation for each will not be the same.

The fourth reason for conservation--fewer inefficient energy uses--generates benefits to the extent of present inefficiencies. The explanation for the seeming irrational consumer decisions is that energy uses are so extensive and varied that consumers cannot obtain sufficient information or cannot afford the extensive analyses that will reveal inefficiencies. This reason for conservation is the easiest to quantify in terms of benefits because the analysis that identifies the inefficiencies also reveals the magnitude of benefits.

The following sub-sections provide more elaborate concepts for measuring benefits and they provide the calculations of numerical estimates presented in Section 3 of this report.

BENEFITS FROM REDUCED POLLUTION

The evaluation of benefits in environmental concerns focuses on two questions: What is the proper measure of willingness-to-pay? What is being paid for?

Figure B.1 pinpoints the answer to the second question and part of the first. Some preliminary explanation will help: pollution is specified as having three sources--(1) energy production and use, (2) nature's own processes, and (3) other activity of man such as incineration of social waste; the optimum overall pollution control is to reduce pollution to "c" percent of present levels, at a cost equal to area cbf in Figure B.1; the optimum pollution control in energy in the context of optimum overall control is to reduce pollution from 100 percent down to "d" percent, at a cost equal to the corresponding shaded area. On the other hand, if pollution control is limited to energy, the optimum control is indicated by point "h", but this is not relevant for our concept.

What people should be willing-to-pay for in energy conservation is

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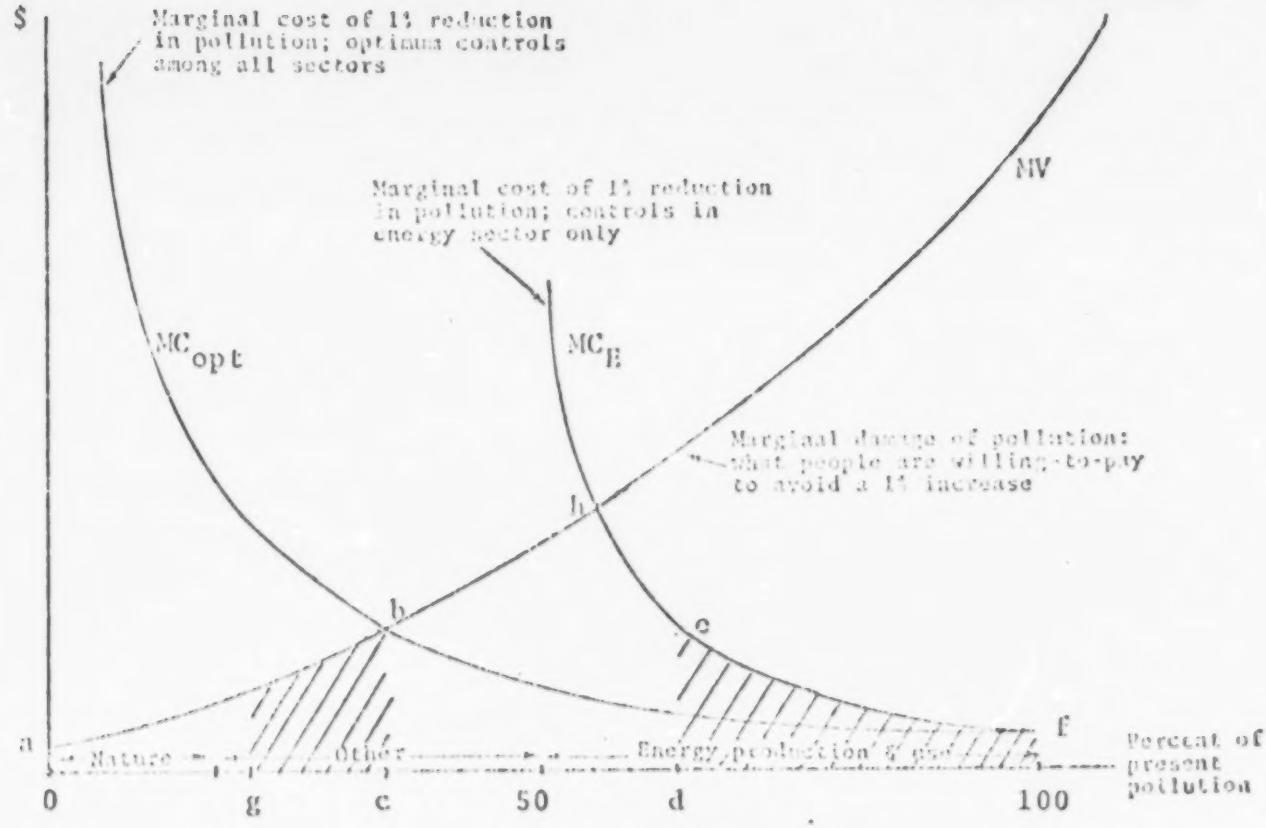

FIGURE B.1: POLLUTION CONTROL BENEFITS IN ENERGY CONSERVATION

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(1) reduction in pollution control costs--the shaded area "def" in the right of Figure B.1--and (2) a reduction in remaining damage--the shaded area "abc" on the left of Figure B.1. In the latter, the pollution damage from energy (the amount "d-50") must be evaluated along the marginal damage line to the left of "c" percent (the marginal pollution from energy after optimum pollution control in all economic sectors).

The marginal reduction in pollution control cost might be less than average costs between "e" and "f" in Figure B.1 if some control technology were already developed. An estimate of the difference is given in the discussion below. The marginal value of reduction in pollution damage will be the percent reduction in energy demand times the shaded area on the left of Figure B.1; this area is the energy portion of remaining pollution.

The answer to the remaining part of "What is the proper measure of willingness-to-pay?" is a choice between two specifications for curve MV up to pollution percent "c" in Figure B.1. One specification is the minimum amount that the public would accept for the right of polluters to add amount "d-50". A second specification is the maximum amount the public would pay to avoid the "d-50" additional pollution. This report does not allow a detailed discussion of the choice, but it seems that the two specifications are probably sufficiently similar for the relatively small pollution between "g" and "c" (equal to "d-50") that willingness-to-pay is acceptable. If reliable data were available, payment that the public is willing to accept for pollution rights is more equitable and, possibly, more efficient than the amount the public is willing to pay for the same.

The 10 percent increased energy cost for pollution control presented in Section 3 corresponds to the shaded area on the right of Figure B.1. The estimated $1.4 billion reduction in pollution control is based on an estimate that control cost for both energy production and energy use among the pre-selected energy reductions is 1.6 of

the average cost between points "e" and "f" in Figure B.1. Therefore, the $1.4 billion approximation is calculated as

$$\$1.4 \text{ billion} = 1.6(.10)(.059)(\$150 \text{ billion energy sales})$$

where .10 is the factor for cost of pollution control described in Section 3 and .059 is the reduction in energy use.

The estimated $.6 billion for reduced pollution damage corresponds to a specific portion of the shaded area on the left-hand side of Figure B.1. The "d-50" percent of pollution designated as the remaining pollution from energy in Figure B.1 is reduced by the fraction of energy cutbacks from conservation in 1980--5.9 percent as shown in Table A.1. However, the "d-50" percent of pollution must be evaluated to the left of point "e" in Figure 1, not at point "d". Using a general factor that 60 percent of pollution damage will be eliminated with optimum pollution control, the $.6 billion approximation of the remaining loss is calculated as

$$\$.59 \text{ billion} = .059 \left[\frac{.40}{.60}\right] .10 \ (\$150 \text{ billion energy sales})$$

where .4/.6 is the ratio of the cost of remaining pollution to the cost of optimum pollution control and .059 is the reduction in energy use

If energy conservation were focused on the greatest pollution remaining after optimum pollution control, the benefits could greatly exceed the $ .6 billion estimate. Energy conservation is another example of how every public program should be focused directly on specific objectives, not merely point in the right direction.

ESTIMATES ON DELAYED DEPLETION

The benefit from delaying the point at which more expensive energy must be used (i.e., delaying depletion) is the cost of foregoing the opportunity--the opportunity to save the energy and use it later to delay the use of more expensive substitutes. If, by chance, the price of new energy is cheaper when the day for its use arrives,

the opportunity cost is zero and there is a net loss from conservation.

The opportunity cost of an energy, say, one barrel of oil, is like the shadow price on oil in a linear programming solution to the problem of allocating all energies to all uses over the planning horizon. The calculations and the estimation of parameters are very difficult but the principle is as simple as the concept of shadow prices in linear programming. The reader can get more details from References 14 and 16 and discussion in Section 3.

The weighted average benefit for the pre-selected eight conservation measures is 11¢/MBTU. The benefits for reduction in crude oil use, for example, is 14¢/barrel. These estimates are first-approximations, but they are the best available at this point in time.

ESTIMATES ON REDUCED VULNERABILITY

Vulnerability to the consequences of sudden increases in supply prices or sudden decreases in quantity supplied is a real concern. The increase in foreign crude oil prices from approximately $2.00 to $12.00/barrel in less than a year has caused losses in the actual outlays and losses in the scramble to adjust to the new prices. The embargo on Arab oil shipments to the United States in 1973 caused hardship that ranged from plant closings to long waiting at gasoline pumps.

Although an embargo can be labeled properly as a restriction on quantity, it should be evaluated as a price increase. Even if market prices do not increase, the shadow price--the true marginal cost under a quantity restriction--does increase. Figure B.2 illustrates normal imports equal to quantity "q_1-q_3", and a shadow price in the first stages of the embargo of p_1. Whereas the long-run

loss from the "q_1-q_2" part of normal supply would be acd/year, the short-run loss is abd/year. Whereas the pure embargo--loss of normal supply "q_1-q_2" but no price increase--causes a loss represented by area abd, the "p" monopoly price causes a loss of abef in Figure B.2.

Calculation of the estimated $.60/barrel in Section 3 is very complex, but its meaning can be described easily. The $.60/unit represents an increase in the normal price $\bar{p}$ to cover the following costs: (1) the optimum storage for reducing shortages like "q_1-q_2", (2) the optimum shut-in capacity that allows a flattening in the shape of the short-run domestic supply curve S_3, and (3) an insurance fund to compensate for losses like abd when they occur. The estimated $.15/barrel in Section 3 represents the value of reducing the probability (a decreasing of the frequency) that an embargo like "q_1-q_2" or price increase like "p_1-$\bar{p}$" in Figure B.2 will occur; it is based on the assumption that a good policy for avoiding the dangers of an embargo would reduce the probability of the same and generate additional benefits of approximately 25% of the $.60/barrel discussed above.

ESTIMATES ON ELIMINATING INEFFICIENCIES

There are few details that can be added to the assumptions that were necessary in developing the estimate of 12 percent of the market price of energy, as described in Section 3. The basic assumption that efforts to decrease energy usage would represent a breaking even at current market prices seems realistic. In some cases, manufacturers undoubtedly err and select an unoptimum tradeoff between energy costs and appliance cost; however, on average, government-specified energy usage standards are as likely to cause cost increases as cost decreases, given consumer tastes, cost of money and market prices to the customer.

Unless the conservation efforts to reduce energy inefficiencies are very carefully selected, the net benefits are only the value of externalities--the difference between market prices and true marginal costs of energy production and use. Since conservation

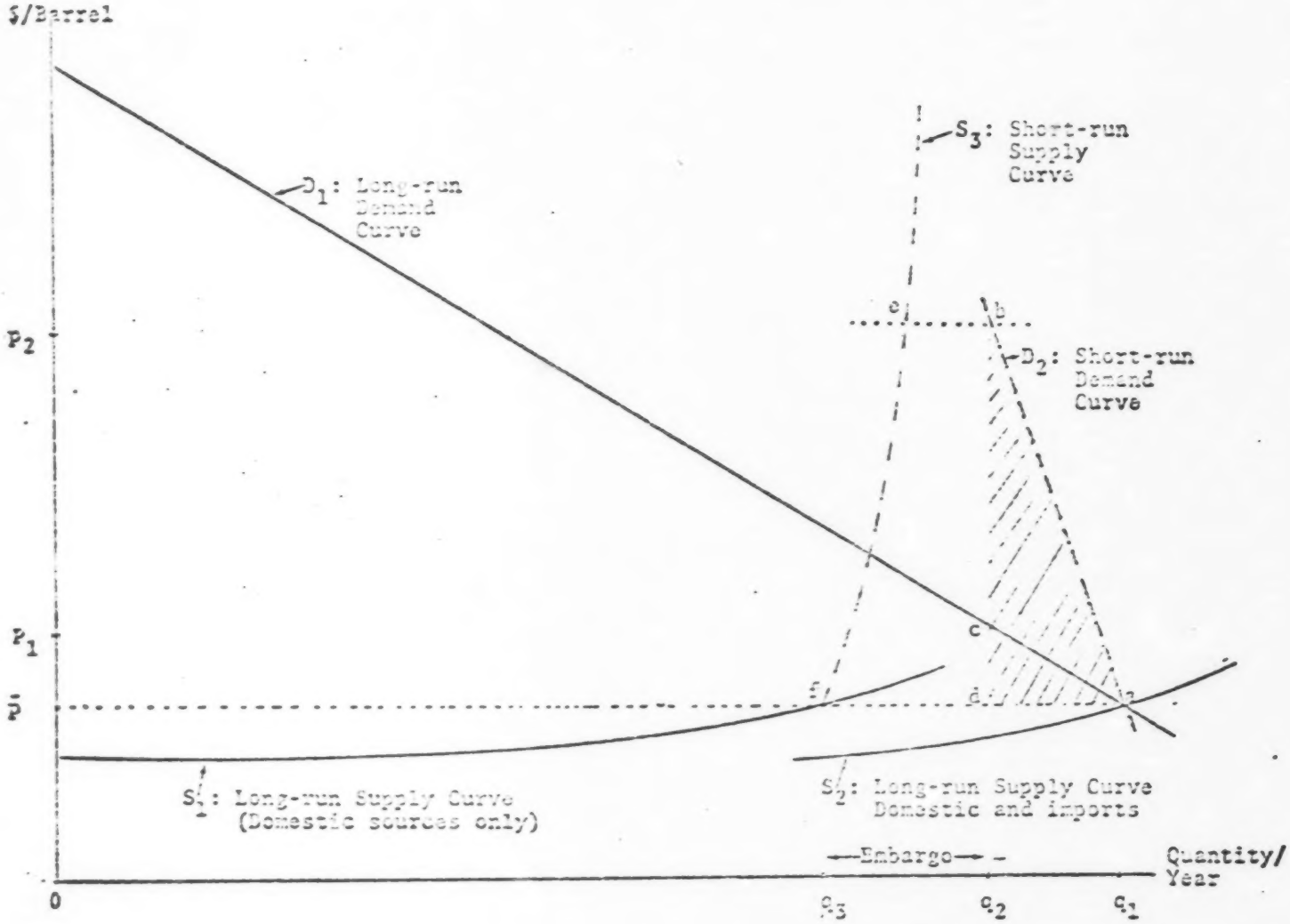

FIGURE 3.2: VULNERABILITY TO EMBARGO AND MONOPOLY PRICING

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only makes sense to the degree it reduces energy use to the point implied by inclusion of externalities in prices, the value/unit of energy from eliminating inefficiencies is the sum of conservation benefits in Categories 1-3 (reducing pollution, delaying energy depletion and reducing vulnerability).

APPENDIX C

CALCULATION OF CONSERVATION IMPACT ON GNP

The specific steps used to calculate the impact in Table 3 are outlined below. The concepts in developing these estimates are discussed in Section 4. Electricity is included in the following calculations of energy and GNP impact.

1. Direct reduction in energy sales (see Table 3)

$$.5 = .10[.40(.11)+.09(.07)+.24(.09)+.27(.05)].69$$

where

.10 is the estimate of the total energy bill as a percentage of GNP in 1980;

.40, .09, .24, .27 are relative shares of energy for residential, commercial, industrial, and transportation sectors respectively, see Table C.1;

.11, .07, .09, .05 are the percentage reduction in energy sales for residential, commercial, industrial, and transportation sectors as specified by Peat, Marwick, Mitchell and Company in their data for our use, see Table A-1; and

.69 is our estimate of the ratio of marginal to average cost of energy. The ratio of marginal to average is important because energy reduction is at the margin.

It should be noted that our estimates are in real dollars rather than current dollars.

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TABLE C.1-CALCULATING THE RELATIVE ENERGY BILL BY SECTOR

	BTUs[a] (10^{15}) (1)	Price per Mil. B Us[b] (2)	Product[c] (10^{9}) (3)	Fraction of Total[d] (4)
Residential	17	$3.00	51	.40
Commercial	12	$1.00	12	.09
Industrial	32	$1.00	32	.24
Transportation	21	$2.00	42	.27

[a] *From p.3 of Peat, Marwick, Mitchell & Co. submission to Jack Faucett Associates, May 1974.*

[b] *From other JFA research on energy costs and consumption.*

[c] *Column 1 times Column 2.*

[d] *Column 3 divided by total for Column 3.*

2. Bottlenecks

The amount of materials and skills, as well as R&D required, were considered in determining feasible schedules for energy savings--schedules that will avoid bottlenecks. Therefore, GNP impact from bottlenecks are assumed to be insignificant relative to the other components in impact.

3. Demand response (see Table 3)

$$.4 = .8(.44).40+1.0(.25).09+.75(1.53).24$$

where

.8, 1.0, .75 are our estimates of the energy demand elasticity for residential, commercial, and industrial sectors. The small demand elasticity in the transportation sector in conjunction with the small price changes makes this component negligible for the overall computation;

.40, .09, .24 are relative shares of energy sales for residential, commercial, and industrial sectors, see Table C.1; and

.44, .25, 1.53 are estimates of the weighted averages of cost changes for the three sectors. These numbers are a function of the energy saved in conservation and estimates of the increase in consumer costs for specified portions of the conservation measures. The calculations are as follows:

Residential $.44 = \frac{1}{2.29}[0(.69)+.5(1.47)+2.0(.14)]$

Commercial $.25 = \frac{1}{1.06}[0(.53)+.5(.53)+2.0(0)]$

Industrial $1.53 = \frac{1}{.40}[0(0)+.5(12)+2.0(.27)]$

where

2.29, 1.06, .40 are the number of quads of energy saved in conservation;

0, .5, 2.0 are factors by which consumer costs will increase (These are best estimates determined after careful consideration of how specific measures will affect sector inputs. No cost information was provided in the input data.); and

the portions of each conservation measure that would fall within the different cost increases were $\frac{.69}{2.29}$, $\frac{1.47}{2.29}$, $\frac{.14}{2.29}$ for the residential sector; $\frac{.53}{1.06}$, $\frac{.53}{1.06}$, $\frac{0}{1.06}$ for the commercial sector; and $\frac{0}{.40}$, $\frac{.12}{.40}$, $\frac{.27}{.40}$ for the industrial sector.

The reader should note a special feature in the cost increases which lead to the demand response estimated above. The cost increases for approximately half of the conservation will be covered by government subsidies; while this reduces cost increases passed on to consumers, it still generates a demand response by lowering consumer after-tax income. The significant variable is the increase in cost of providing goods and services because demand responds to lower income as well as higher prices.

4. Multiplier effect (See Table 3)

.5 = .5(.58+0+.44)

where .5 is the net increase from a 1.5 multiplier in 1980[1]; and

.58, 0, .44 are the impacts from reduction in energy sales, bottlenecks, and demand falloff.

[1] *A multiplier of 1.5 is reasonable given the warning on conservation and opportunities for spending money saved on energy for other products.*

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